

FIRE-RETARDANT RESIN COMPOSITION  
AND MOLDED PART USING THE SAME

FIELD OF THE INVENTION

5           The present invention relates to a fire-retardant resin composition excellent in mechanical characteristics and flexibility, as well as heat resistance, and to a wiring material and an optical fiber cord in which said composition is used as a covering material, and other  
10   molded parts.

          More specifically, the present invention relates to a fire-retardant resin composition preferably suitable as a covering material for insulated wires, electric cables, and electric cords, which are used for inner and outer  
15   wiring of electric/electronic equipment, optical fiber core wires, optical fiber cords, etc.; and to a wiring material and other molded parts in which use is made of the same. More particularly, the present invention relates to a fire-retardant resin composition that neither  
20   exudes heavy metal compounds nor produces a large amount of smoke or corrosive gases when discarded, for example, to be buried or burned, and that can be recycled after its use, so that environmental problems may be cleared, and to a wiring material and other molded parts in which use is  
25   made of the same.

## BACKGROUND OF THE INVENTION

Insulated wires, cables, and cords, which are used for inner and outer wiring of electric/electronic equipment, optical fiber cores, and optical fiber cords, are required to have various characteristics, including fire retardancy, heat resistance, and mechanical characteristics (e.g. tensile properties and abrasion resistance).

For this reason, as the covering material used for these wiring materials, a polyvinyl chloride (PVC) compound and a polyolefin compound, wherein a halogen-series fire-retardant additive containing bromine atoms or chlorine atoms in the molecule is mixed, have been mainly used.

In some cases, however, when they are discarded or buried without being treated properly, the plasticizer or the heavy metal stabilizer mixed in the covering material is oozed out, or when they are burned, a corrosive gas is produced from the halogen compound contained in the covering material, in some cases; and in recent years, this problem has become controversial.

Therefore, wiring materials covered with a halogen-free fire-retardant material free from any risk of oozing out of toxic plasticizers or heavy metals, or generation

of a halogen-series gas or the like, which involves concern about affecting the environment, are investigated.

Halogen-free fire-retardant materials secure their fire-retardancy by mixing a halogen-free fire-retardant additive in a resin. For example, a material obtained by mixing a large amount of a metal hydrate, such as aluminum hydroxide and magnesium hydroxide, as a fire-retardant additive, in an ethylene-series copolymer, such as an ethylene/1-butene copolymer, an ethylene/propylene copolymer, an ethylene/vinyl acetate copolymer, an ethylene/ethyl acrylate copolymer, and an ethylene/propylene/diene terpolymer, is used as a wiring material.

The standards, for example, of the fire retardancy, the heat resistance, and the mechanical characteristics (e.g. tensile properties and abrasion resistance) required for wiring materials of electric/electronic equipment are stipulated in UL, JIS, etc. In particular, with respect to the fire retardancy, its test method varies depending on the required level (its use to be applied) and the like. Therefore, practically, it is enough for the material to have at least the fire retardancy according to the required level. For example, mention can be made the respective fire-retardancy to pass the vertical flame test (VW-1) stipulated in UL 1581 (Reference Standard for

Electrical Wires, Cables, and Flexible Cords), or the horizontal test and the inclined test stipulated in JIS C 3005 (rubber/plastic insulated wire test method).

Among these, hitherto, when a halogen-free fire-retardant material is made to have a fire retardancy high enough to pass VW-1 and the inclined test, it is necessary to mix 120 parts by weight or more of a metal hydrate, as a fire-retardant additive, in 100 parts by weight of a resin component, such as an ethylene-series copolymer. As a result, there is a problem that the mechanical characteristics, such as the tensile properties and the abrasion resistance, of the covering material are markedly lowered. To solve this problem, a measure is taken to lower the proportion of the metal hydrate (e.g. about 120 parts by weight of a metal hydrate, as a fire-retardant additive, to 100 parts by weight of a resin), and red phosphorus is added.

Meanwhile, wiring materials that are currently used in electric/electronic equipment, and whose covering material is a polyvinyl chloride compound or a polyolefin compound, wherein a halogen-series fire-retardant additive is mixed, are used by coloring them to be several respective colors, for example, by printing the surface of electric wires, electric cables, and electric cords, for the purpose of distinguishing the types of wiring

materials and junctions. However, halogen-free covering materials having a metal hydrate and red phosphorus mixed therein, to secure both a higher fire retardancy and mechanical characteristics, cannot be printed thereon, or  
5 they cannot be arbitrarily colored because of the color of the red phosphorus, so that they have the problem that they cannot give wiring materials that allow the types and junctions to be distinguished easily. Further, phosphorus, which will be released after discarding of the fire-  
10 retardant material containing phosphorus, poses also a problem that affects the environment; for example, pollution of water by eutrophication.

Further, wiring materials used in electric/electronic equipment are sometimes required to  
15 have a heat resistance of 80 to 105 °C, or even 125 °C, with them being used continuously.

In that case, such a method is taken that the covering material is crosslinked by an electron beam crosslinking method, or a chemical crosslinking method, in  
20 order to render the wiring material highly heat resistant.

However, while the crosslinked wiring material is improved in the heat resistance of the covering material, it is impossible to remelt it. Therefore it is pointed out that it is difficult to use said material again,  
25 making the recyclability thereof poor. For example, when a

metal used as a conductor is recovered, the covering material has, for example, to be burned, in many cases, which means that the above environmental problem involving the conventional halogen- or phosphorus-containing covering material cannot be avoided.

On the other hand, as a technique wherein a wiring material having a heat resistance, on the order of 105 °C, is realized without carrying out such crosslinking, there is a technique wherein a resin having a high melting point, such as a polypropylene-series resin, is used. However, although such a resin is good in heat resistance, the flexibility is poor, and when the wiring material covered with such a resin is bent, a phenomenon is observed that the surface is whitened.

This whitening phenomenon is not observed in wiring materials currently used in electric/electronic equipment and covered with a polyvinyl chloride compound. On the other hand, in the case of wiring materials covered with a halogen-free fire-retardant material wherein a large amount of a metal hydroxide is mixed, this whitening phenomenon is conspicuous regardless of whether they have been subjected to the crosslinking process or not. Thus, to use the current halogen-free fire-retardant material, which is whitened when bent, for wiring materials, further improvement has been required.

Since the maximum service temperature of a wiring material covered with a polyvinyl chloride compound is on the order of UL 105 °C, a halogen-free fire-retardant material for use as a replacement for the wiring material is also required to have that heat resistance. Specifically, since, for a heat resistance of UL 105 °C, for example, the heat deformation test and the heat aging test in an atmosphere at 136 °C are required, the halogen-free fire-retardant material, as a replacement, is required to not melt at at least 136 °C.

In addition, molded parts, such as power source plugs, have the similar problems as the above, and the development of molded parts has been desired, which have heat resistance, flexibility, and fire retardancy, which can be recycled, and which can be remolded.

#### SUMMARY OF THE INVENTION

An object of the present invention is to provide a fire-retardant resin composition that solves the above problems, that is excellent in fire retardancy, heat resistance, and mechanical characteristics, and that neither exudes heavy metal compounds nor produces a large amount of smoke or corrosive gases when discarded, for example, to be buried or burned, so that recent environmental problems may be cleared. Another object of

the present invention is to provide a molded article that solves the above problems, that is excellent in fire retardancy, heat resistance, and mechanical characteristics, and that neither exudes heavy metal compounds nor produces a large amount of smoke or corrosive gases when discarded, for example, to be buried or burned, so that recent environmental problems may be cleared. Further object of the present invention is to provide a fire-retardant resin composition that gives a covering material that can be remelted, to allow it to be reused; that is not whitened when bent, and that is not easily scarred, while satisfying the above characteristics. Still another object of the present invention is to provide a wiring material, an optical fiber core, an optical fiber cord, and other molded parts wherein said composition is used, respectively.

Other and further objects, features, and advantages of the invention will appear more fully from the following description, taken in connection with the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross-sectional view of an example of the optical fiber core wire of the present invention having a covering layer provided directly around the outer



circumference of an optical fiber element wire.

Fig. 2 is a cross-sectional view of an example of the optical fiber cord of the present invention wherein a covering layer is formed around the outer circumference of one optical fiber core wire along which a plurality of tensile strength fibers are placed (in a longitudinal direction).

Fig. 3 is a cross-sectional view of another example of the optical fiber cord of the present invention wherein a plurality of tensile strength fibers are placed along each of the outer circumferences of two optical fiber core wires and a covering layer is formed around the resulting outer circumferences.

Fig. 4 is a front view of an apparatus for testing abrasion resistance.

Fig. 5 is a front view of the blade in the apparatus for testing abrasion resistance, as shown in Fig. 4.

Fig. 6 is a schematic view showing a method for testing flexibility.

#### DETAILED DESCRIPTION OF THE INVENTION

To attain the above objects, in the present invention, there are provided:

(1) A fire-retardant resin composition, which comprises:

a thermoplastic resin component (A) comprising (a) 100 parts by weight of a block copolymer made up of at least two polymer blocks A mainly made of a vinyl aromatic compound as its constitutional component and at least one  
5 polymer block B mainly made of a conjugated diene compound as its constitutional component, and/or a hydrogenated block copolymer obtained by hydrogenating the block copolymer, (b) 10 to 100 parts by weight of a nonaromatic-series softening agent for rubber, (c) 30 to 400 parts by  
10 weight of an ethylene/ $\alpha$ -olefin copolymer, and (d) 0 to 200 parts by weight of a polypropylene resin; and

(e) 0.01 to 0.6 parts by weight of an organic peroxide, (f) 0.03 to 1.8 parts by weight of a (meth)acrylate-series and/or allyl-series crosslinking aid,  
15 and 50 to 300 parts by weight of a metal hydrate (B), respectively to 100 parts by weight of the thermoplastic resin component (A),

wherein the metal hydrate (B) is such that (i) when the metal hydrate (B) is in an amount of 50 parts by  
20 weight or more but less than 100 parts by weight, 50 parts by weight or more of the metal hydrate (B) to 100 parts by weight of the thermoplastic resin component (A) is made up of a metal hydrate that is being pretreated with a silane coupling agent; or (ii) when the metal hydrate (B) is in  
25 an amount of 100 parts by weight or more but 300 parts by

weight or less, at least half of the amount of the metal hydrate (B) is made up of a metal hydrate that is being pretreated with a silane coupling agent; and

the fire-retardant resin composition is a mixture of the  
5 above formulation that is heated and kneaded at a temperature equal to or higher than the melting temperature of the thermoplastic resin component (A);

(2) A fire-retardant resin composition, which comprises:

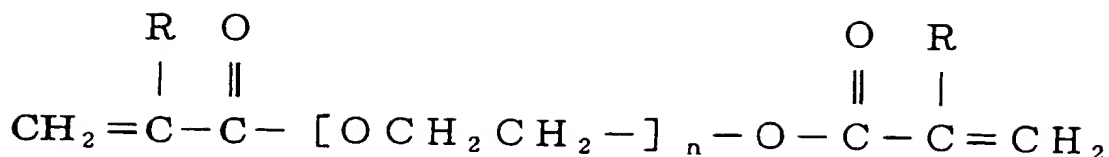
10 a thermoplastic resin component (A) comprising (a) 100 parts by weight of a block copolymer made up of at least two polymer blocks A mainly made of a vinyl aromatic compound as its constitutional component and at least one polymer block B mainly made of a conjugated diene compound  
15 as its constitutional component, and/or a hydrogenated block copolymer obtained by hydrogenating the block copolymer, (b) 10 to 100 parts by weight of a nonaromatic-series softening agent for rubber, (c) 50 to 250 parts by weight of an ethylene/ $\alpha$ -olefin copolymer, and (d) 0 to 100  
20 parts by weight of a polypropylene resin; and

(e) 0.01 to 0.6 parts by weight of an organic peroxide, (f) 0.03 to 1.8 parts by weight of a (meth)acrylate-series and/or allyl-series crosslinking aid, and 50 to 300 parts by weight of a metal hydrate (B),  
25 respectively to 100 parts by weight of the thermoplastic

resin component (A),

wherein the metal hydrate (B) is such that (i) when the metal hydrate (B) is in an amount of 50 parts by weight or more but less than 100 parts by weight, 50 parts  
5 by weight or more of the metal hydrate (B) to 100 parts by weight of the thermoplastic resin component (A) is made up of a metal hydrate that is being pretreated with a silane coupling agent; or (ii) when the metal hydrate (B) is in an amount of 100 parts by weight or more but 300 parts by  
10 weight or less, at least half of the amount of the metal hydrate (B) is made up of a metal hydrate that is being pretreated with a silane coupling agent; and the fire-retardant resin composition is a mixture of the above formulation that is heated and kneaded at a  
15 temperature equal to or higher than the melting temperature of the thermoplastic resin component (A);

(3) The fire-retardant resin composition as stated in the above (1) or (2), wherein the crosslinking aid (f) is a (meth)acrylate-series crosslinking aid represented by  
20 the formula:



wherein R represents H or CH<sub>3</sub>, and n is an integer of 1 to 9;

(4) The fire-retardant resin composition as stated  
10 in any one of the above (1) to (3), wherein the metal hydrate (B) is magnesium hydroxide;

(5) The fire-retardant resin composition as stated  
in any one of the above (1) to (4), wherein the silane coupling agent is a silane compound having a vinyl group  
15 and/or an epoxy group at its terminal;

(6) A molded article, which has a covering layer of the fire-retardant resin composition as stated in any one of the above (1), and (3) to (5), on the outside of a conductor, or an optical fiber element wire or/and an  
20 optical fiber core wire;

(7) A molded part, which is obtained by molding the fire-retardant resin composition as stated in any one of the above (2) to (5);

(8) A method for preparing a fire-retardant resin  
25 composition that is the fire-retardant resin composition

as stated in any one of the above (1) to (5), which comprises:

heating and kneading, simultaneously, at the temperature equal to or higher than the melting

5 temperature of the thermoplastic resin component (A), (a) the block copolymer made up of at least two polymer blocks A mainly made of a vinyl aromatic compound as its constitutional component and at least one polymer block B mainly made of a conjugated diene compound as its  
10 constitutional component, and/or the hydrogenated block copolymer obtained by hydrogenating the block copolymer, (b) the nonaromatic-series softening agent for rubber, (c) the ethylene/ $\alpha$ -olefin copolymer, (d) the polypropylene resin, (e) the organic peroxide, (f) the (meth)acrylate-series and/or allyl-series crosslinking aid, and the metal  
15 hydrate (B), to carry out crosslinking; and

(9) A method for preparing a fire-retardant resin composition that is the fire-retardant resin composition as stated in any one of the above (1) to (5), which  
20 comprises:

a first step of heating and kneading (a) the block copolymer made up of at least two polymer blocks A mainly made of a vinyl aromatic compound as its constitutional component and at least one polymer block B mainly made of  
25 a conjugated diene compound as its constitutional

component, and/or the hydrogenated block copolymer  
obtained by hydrogenating the block copolymer, (b) the  
nonaromatic-series softening agent for rubber, (c) the  
ethylene/ $\alpha$ -olefin copolymer, and (d) the polypropylene  
5 resin, to obtain the thermoplastic resin component (A),  
and

a second step of heating and kneading, at the  
temperature equal to or higher than the melting  
temperature of the thermoplastic resin component (A), the  
10 resultant resin component (A), (e) the organic peroxide,  
(f) the (meth)acrylate-series and/or allyl-series  
crosslinking aid, and the metal hydrate (B), to carry out  
crosslinking.

In the present invention, by properly setting, in  
15 the above-described range, the amount of the organic  
peroxide contained at the same time with the resin  
ingredients, and the amount and the type of the  
crosslinking aid, it is possible to make the crosslinked  
structure loose and low in crosslink density, as well as  
20 by selecting a specific metal hydrate, a large amount of  
the metal hydrate can be added.

Hereinbelow, the present invention is described in  
detail.

First, the individual ingredients of the fire-  
25 retardant resin composition of the present invention are

described.

(A) Thermoplastic Resin Component

The thermoplastic resin component (A) comprises (a)  
a block copolymer made up of at least two polymer blocks A  
5 mainly made of a vinyl aromatic compound as its  
constitutional component and at least one polymer block B  
mainly made of a conjugated diene compound as its  
constitutional component, and/or a hydrogenated block  
copolymer obtained by hydrogenating the block copolymer,  
10 (b) a nonaromatic-series softening agent for rubber, (c)  
an ethylene/ $\alpha$ -olefin copolymer, and (d) a polypropylene  
resin.

(a) Ingredient: Block Copolymer

The ingredient (a) for use in the present invention  
15 is a block copolymer that is made up of at least two  
polymer blocks A, which is mainly made of a vinyl aromatic  
compound as its constitutional component, and at least one  
polymer block B, which is mainly made of a conjugated  
diene compound as its constitutional component, or it is a  
20 hydrogenated block copolymer obtained by hydrogenating the  
block copolymer, or it is a mixture of these. Examples of  
the ingredient (a) include a vinyl aromatic  
compound/conjugated diene compound block copolymer having  
a structure of A-B-A, B-A-B-A, A-B-A-B-A, or the like, or  
25 one obtained by hydrogenating the block copolymer. The



above (hydrogenated) block copolymer (hereinafter, by a (hydrogenated) block copolymer is meant a block copolymer and/or a hydrogenated block copolymer) contains generally 5 to 60 % by weight and preferably 20 to 50 % by weight of a vinyl aromatic compound.

Preferably the polymer block A mainly made of a vinyl aromatic compound as its constitutional component, consists only of a vinyl aromatic compound, or it is a copolymer block of a vinyl aromatic compound in an amount of generally 50 % by weight or more and preferably 70 % by weight or more with a (hydrogenated) conjugated diene compound (hereinafter, by a (hydrogenated) conjugated diene compound is meant a conjugated diene compound and/or a hydrogenated conjugated diene compound). The polymer block B mainly made of a (hydrogenated) conjugated diene compound as its constitutional component, is preferably consisted only of a (hydrogenated) conjugated diene compound, or it is a copolymer block of a (hydrogenated) conjugated diene compound in an amount of generally 50 % by weight or more and preferably 70 % by weight or more with a vinyl aromatic compound. In each of the polymer block A mainly made of a vinyl aromatic compound as its constitutional component and the polymer block B mainly made of a (hydrogenated) conjugated diene compound as its constitutional component, the distribution of the

repeating units in the molecular chain, which are derived from the vinyl aromatic compound or the (hydrogenated) conjugated diene compound, may be a random distribution, a tapered distribution (one wherein the monomer component is increased or decreased along the molecular chain), a partial block distribution, or any combination of these. When there are two or more polymer blocks A mainly made of a vinyl aromatic compound as its constitutional component or two or more polymer blocks B mainly made of a (hydrogenated) conjugated diene compound as its constitutional component, the structures thereof are the same or different.

As the vinyl aromatic compound constituting the (hydrogenated) block copolymer, for example, one or more of styrene,  $\alpha$ -methylstyrene, vinyltoluene, p-tert-butylstyrene, and the like can be chosen, with preference given to styrene. Further, as the conjugated diene compound, for example, one or more of butadiene, isoprene, 1,3-pentadiene, 2,3-dimethyl-1,3-butadiene, and the like are chosen, and among these butadiene, isoprene, and a combination of these are preferable.

As the microstructure of the polymer block B mainly made of a conjugated diene compound as its constitutional component, any microstructure may be chosen. For example, in the case of a polybutadiene block, those wherein a 1,2-

microstructure amounts to 20 to 50 % and particularly 25 to 45 % are preferable, and those wherein at least 90 % of aliphatic double bonds derived from butadiene are hydrogenated are preferable. In the case of a

5 polyisoprene block, those wherein 70 to 100 % by weight of the isoprene compound has a 1,4-microstructure and at least 90 % of aliphatic double bonds derived from the isoprene compound is hydrogenated are preferable.

The weight-average molecular weight of the  
10 (hydrogenated) block copolymer used in the present invention that has the above structure, is preferably in the range of 5,000 to 1,500,000, more preferably 10,000 to 550,000, further preferably 100,000 to 550,000, and particularly preferably 100,000 to 400,000. The molecular  
15 weight distribution (the ratio ( $M_w/M_n$ ) of the weight-average molecular weight ( $M_w$ ) to the number-average molecular weight ( $M_n$ )) is preferably 10 or less, more preferably 5 or less, and further preferably 2 or less. The molecular structure of the (hydrogenated) block  
20 copolymer may be a straight-chain structure, a branched-chain structure, a radial structure, or any combination thereof.

As the method for preparing the (hydrogenated) block copolymer, many methods have been proposed, and as a  
25 representative method, for example, a method described in

JP-B-40-23798 ("JP-B" means examined Japanese patent publication) can be used, by which method block polymerization in an inactive solvent is carried out using a lithium catalyst or a Ziegler-type catalyst, to obtain the block copolymer. Further, for example, the block copolymer obtained by the above method may be hydrogenated in an inactive solvent, in the presence of a hydrogenation catalyst, to obtain a (hydrogenated) block copolymer.

As specific examples of the above (hydrogenated) block copolymer, SBS (styrene/butadiene block copolymer), SIS (styrene/isoprene block copolymer), SEBS (hydrogenated SBS), and SEPS (hydrogenated SIS) can be mentioned. In the present invention, a particularly preferable (hydrogenated) block copolymer is a hydrogenated block copolymer that comprises a polymer block A mainly made of styrene as its constitutional component and a polymer block B mainly made of isoprene as its constitutional component, wherein 70 to 100 % by weight of isoprene has a 1,4-microstructure and at least 90 % of aliphatic double bonds derived from the isoprene is hydrogenated, and it has a weight-average molecular weight of 50,000 to 550,000. More preferably in the above hydrogenated block copolymer, 90 to 100 % by weight of isoprene has a 1,4-microstructure.

(b) Ingredient: Nonaromatic-series Softening Agent  
(Softener) for Rubber

As the ingredient (b) for use in the present invention, a nonaromatic-series mineral oil, or liquid or low-molecular-weight synthetic softener can be used.

The mineral oil softener used for rubbers is a combined mixture of three of an aromatic ring, a naphthene ring, and a paraffin chain, which is distinguished as follows: one wherein the number of carbon atoms of the paraffin chain amounts to 50 % or more of the total number of carbon atoms is referred to as paraffinic-series, one  
10 wherein the number of carbon atoms of the naphthene ring amounts to 30 to 40 % of the total number of carbon atoms is referred to as naphthenic-series, and one wherein the number of carbon atoms of the aromatic ring amounts to 30 % or more is referred to as aromatic-series.

15 The mineral-oil-series softener for rubber used as the ingredient (b) for use in the present invention, is one that is paraffinic-series or naphthenic-series as distinguished above. The use of an aromatic-series softener makes the ingredient (a) soluble, to inhibit the  
20 crosslinking reaction, which is unpreferable because the physical properties of the obtainable composition cannot be improved. As the ingredient (b), a paraffinic-series softener is preferable, and among paraffinic-series softeners, one having less aromatic ring component is  
25 particularly preferable.

Preferably the properties of these nonaromatic-series softeners for rubber are such that the kinetic viscosity at 37.8 °C is 20 to 500 cSt, the pour point is -10 to -15 °C, and the flash point (COC) is 170 to 300 °C.

5       The amount of the ingredient (b) to be added is 10 to 100 parts by weight and preferably 30 to 70 parts by weight, to 100 parts by weight of the ingredient (a). If the amount to be added is less than 10 parts by weight, the obtainable wiring material will lose the flexibility.

10       On the other hand, if the amount to be added is over 100 parts by weight, the softening agent bleeds out readily, leading to a fear that the wiring material is made sticky and lowering the mechanical properties thereof.

Part of the ingredient (b) can be added after the

15       heat treatment in the presence of the peroxide, but it may cause bleed-out in some cases.

Preferably the ingredient (b) has a weight-average molecular weight of 100 to 2,000.

(c) Ingredient: Ethylene/ $\alpha$ -Olefin Copolymer

20       As the ingredient (c) for use in the present invention, an ethylene/ $\alpha$ -olefin copolymer is used.

Preferably the ethylene/ $\alpha$ -olefin copolymer (c) is a copolymer of ethylene with an  $\alpha$ -olefin having 3 to 12 carbon atoms, and as specific examples of the  $\alpha$ -olefin,

25       can be mentioned propylene, 1-butene, 1-hexene, 4-methyl-

1-pentene, 1-octene, 1-decene, and 1-dodecene. In the ingredient (c), when the  $\alpha$ -olefin is a propylene, the content of the propylene component is less than 50%.

The ethylene/ $\alpha$ -olefin copolymer includes, for example, LLDPE (straight-chain low-density polyethylene), LDPE (low-density polyethylene), VLDPE (very low density polyethylene), and an ethylene/ $\alpha$ -olefin copolymer synthesized in the presence of a single site catalyst. Out of these, the ethylene/ $\alpha$ -olefin copolymer synthesized in the presence of a single site catalyst is preferable taking the acceptability of a filler to be loaded and the flexibility of the resin composition intended by the present invention into consideration. Preferably the density of the copolymer is  $0.93 \text{ g/cm}^3$  or less, more preferably  $0.925 \text{ g/cm}^3$  or less, and particularly preferably  $0.92 \text{ g/cm}^3$  or less. There is no particular lower limit to the density, but generally the lower limit is  $0.850 \text{ g/cm}^3$ .

Further, preferably the ethylene/ $\alpha$ -olefin copolymer (c) has a melt flow index (ASTM D-1238) of 0.5 to 30 g/10 min.

To prepare the ethylene/ $\alpha$ -olefin copolymer synthesized in the presence of a single site catalyst for use in the present invention, a known method described, for example, in JP-A-6-306121 ("JP-A" means unexamined

published Japanese patent application) or JP-T-7-500622  
("JP-T" means a published Japanese translation of PCT  
international application) can be used.

The single site catalyst is one whose polymerization  
5 active point is single and it is high in polymerization  
activity, and the single site catalyst is also called as a  
metallocene catalyst or a Kaminsky catalyst. The  
ethylene/ $\alpha$ -olefin copolymer synthesized using this  
catalyst is characterized in that the molecular  
10 distribution and the composition distribution are narrow.

Since the ethylene/ $\alpha$ -olefin copolymer synthesized in  
the presence of such a single site catalyst has, for  
example, a high tensile strength, tear strength, and  
impact strength, when it is used in a halogen-free fire  
15 retardant material (a covering material of a wiring  
material) that is required to be highly filled with a  
metal hydrate, there is obtained an advantage that the  
lowering of the mechanical characteristics due to the  
highly filled metal hydrate can be minimized.

20 In contrast, in comparison with the use of the usual  
ethylene/ $\alpha$ -olefin copolymer, the use of the ethylene/ $\alpha$ -  
olefin copolymer synthesized using a single site catalyst  
causes an increase in melt viscosity or a decrease in melt  
tension, causing a problem with moldability. In this  
25 regard, there is one wherein the moldability is improved



by introducing long-chain branches using an asymmetric catalyst as a single site catalyst (Constrained Geometry Catalytic Technology) or forming two peaks in the molecular weight distribution by connecting two  
5 polymerization tanks at the time of the polymerization (Advanced Performance Terpolymer).

Preferably, the ethylene/ $\alpha$ -olefin copolymer (c) synthesized in the presence of a single site catalyst used in the present invention, is the above one improved in  
10 moldability, and as examples thereof "AFFINITY" and "ENGAGE" (trade names) from Dow Chemical Co. and "EXACT" (trade name) from Exxon Chemical Co. are put on the market.

When the fire retardant resin composition of the present invention is used as a covering material, for  
15 example, of insulated wires, electric cables, electric cords, optical fiber core wires, and optical fiber cords, the amount of the ingredient (c) to be added, to 100 parts by weight of the ingredient (a), is from 30 to 400 parts by weight, preferably from 50 to 300 parts by weight, and  
20 more preferably from 50 to 200 parts by weight. If the amount to be added is less than 30 parts by weight, a high filling of a metal hydrate becomes difficult, causing a problem that the mechanical characteristics of the obtainable composition are lowered. On the other hand, if  
25 the amount to be added is over 400 parts by weight, there

arises a problem that the flexibility is lost and the nonaromatic-series softening agent for rubber bleeds out from the resultant composition.

Further, when the fire-retardant resin composition of the present invention is used in a molded part, the amount of the ingredient (c) to be added, to 100 parts by weight of the ingredient (a), is from 50 to 250 parts by weight. When the amount to be added is in this range, the moldability is particularly readily secured and the mechanical characteristics are satisfactory for the molded part.

(d) Ingredient: Polypropylene Resin

As the polypropylene resin that can be used in the present invention, can be mentioned, for example, a homopolypropylene, an ethylene/propylene random copolymer, an ethylene/propylene block copolymer, and a copolymer of propylene with a small amount of another  $\alpha$ -olefin (e.g., 1-butene, 1-hexene, and 4-methyl-1-pentene).

Herein, the ethylene/propylene random copolymer means one in which the content of the ethylene component is in a range of about 1 to 4 wt%, and the ethylene/propylene block copolymer means one in which the content of the ethylene component is in a range of about 5 to 20 wt%.

In the present invention, the ingredient (d), a

polypropylene resin, can be used in such a way that part thereof is added after the heating and kneading, in the preparation of the resin component (A) that is heated and kneaded to form a partially crosslinked product.

5           The polypropylene resin mixed in (A) before the heating and kneading is thermally decomposed due to the presence of the ingredient (e) in the subsequent heating and kneading, thereby the molecular weight is suitably lowered.

10           As the polypropylene resin that is mixed before the heating and kneading, preferably one having an MFR (ASTM-D-1238, L conditions, 230 °C) of 0.1 to 10 g/10 min, more preferably 0.1 to 5 g/10 min, and further preferably 0.1 to 3 g/10 min is used.

15           If the MFR of the polypropylene resin is less than 0.1 g/10 min, even after the heat treatment, the molecular weight of the polypropylene resin is not lowered, making the moldability of the obtainable resin composition (elastomer) poor in some cases, whereas if the MFR of the  
20 polypropylene resin is over 10 g/10 min, the molecular weight is too lowered, making the rubber elasticity of the obtainable resin composition poor in some cases.

          As the polypropylene resin that is mixed after the heating and kneading, one that meets the conditions at the  
25 time of extrusion for the formation of a covering layer is

suitable, and preferably the MFR is 5 to 200 g/10 min, more preferably 8 to 150 g/10 min, and further preferably 10 to 100 g/10 min.

When the mixing is carried out after the heating and kneading, if the MFR of the polypropylene resin is less than 5 g/10 min, the moldability of the obtainable resin composition is made poor in some cases, whereas if the MFR is over 200 g/10 min, the rubber elasticity of the obtainable resin composition is made poor in some cases.

When the fire-retardant resin composition of the present invention is used as a covering material, for example, for insulated wires, electric cables, electric cords, optical fiber core wires, and optical fiber cords, the amount of the ingredient (d) to be added, to 100 parts by weight of the ingredient (a), is from 0 to 200 parts by weight, preferably from 0 to 60 parts by weight, and further preferably from 10 to 60 parts by weight. If the amount of the polypropylene resin (d) to be added is over 200 parts by weight, there is a problem that the resin composition becomes hard, making the flexibility poor.

Meantime, although the ingredient (d) serves to make the extrudability of the resin composition favorable with the heat resistance secured, the ingredient (d) can be omitted if a high heat resistance is not needed. If the ingredient (d) is not used, generally the amount of the

ingredient (b) to be used is controlled, to secure a resin composition good in extrudability in its entirety.

Further, if the fire-retardant resin composition of the present invention is used in a molded part, the amount of the ingredient (d) to be added, to 100 parts by weight of the ingredient (a), is from 0 to 100 parts by weight. If the amount to be added is in this range, the moldability is particularly readily secured and the mechanical characteristics are satisfactory for the molded part.

(e) Ingredient: Organic Peroxide

As the organic peroxide that can be used in the present invention, can be mentioned, for example, dicumyl peroxide, di-tert-butyl peroxide, 2,5-dimethyl-2,5-di-(tert-butyl peroxy)hexane, 2,5-dimethyl-2,5-di(tert-butyl peroxy)hexane-3, 1,3-bis(tert-butyl peroxyisopropyl)benzene, 1,1-bis(tert-butyl peroxy)-3,3,5-trimethylcyclohexane, n-butyl-4,4-bis(tert-butyl peroxy)valerate, benzoyl peroxide, p-chlorobenzoyl peroxide, 2,4-dichlorobenzoyl peroxide, tert-butyl peroxybenzoate, tert-butyl peroxyisopropyl carbonate, diacetyl peroxide, lauroyl peroxide, and tert-butylcumyl peroxide.

Out of these, 2,5-dimethyl-2,5-di-(tert-butyl peroxy)hexane and 2,5-dimethyl-2,5-di-(tert-butyl

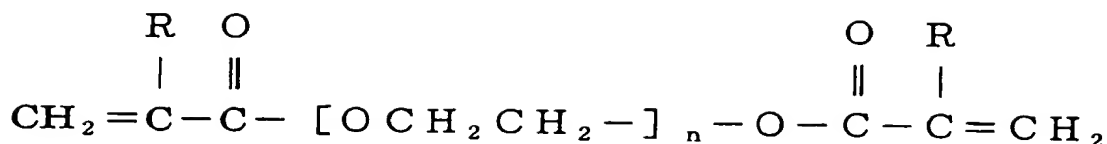
peroxy)hexine-3 are most preferable, in view of the odor, the coloration, and the scorch stability.

The amount of the organic peroxide (e) to be added, to 100 parts by weight of the thermoplastic resin

5 component (A), is in the range of 0.01 to 0.6 part by weight, and preferably 0.1 to 0.6 part by weight. By choosing the organic peroxide in this range, a partially crosslinked composition excellent in extrudability can be obtained without granular structure to occur, because the  
10 crosslinking does not proceed excessively.

(f) Ingredient: (Meth)acrylate-Series and/or Ally-Series Crosslinking Aid

In the preparation of the fire-retardant resin composition of the present invention or the thermoplastic  
15 resin component (A) used therein, a partially crosslinked structure is formed between the vinyl aromatic thermoplastic elastomer and the ethylene/ $\alpha$ -olefin copolymer through a crosslinking aid, in the presence of the organic peroxide. As the crosslinking aid used at  
20 that time, a (meth)acrylate-series crosslinking aid represented by the formula:



wherein R represents a hydrogen atom or a methyl group, and n is an integer of 1 to 9, can be mentioned. Herein, by the (meth)acrylate-series crosslinking aid is meant acrylate-series and methacrylate-series crosslinking aids. Specifically, ethylene glycol dimethacrylate, diethylene glycol dimethacrylate, triethylene glycol dimethacrylate, a polyethylene glycol dimethacrylate, trimethylolpropane trimethacrylate, and allyl methacrylate can be mentioned.

In addition, those having an ally group at the terminal, such as dially fumarate, dially phthalate, tetraally oxyethane, and trially cyanurate, can be used.

Out of the above, particularly a (meth)acrylate-series crosslinking aid wherein n is 1 to 6 is preferable, including ethylene glycol diacrylate, triethylene glycol dimethacrylate, and tetraethylene glycol dimethacrylate.

Particularly, in the present invention, triethylene glycol dimethacrylate is most preferable, because it can be easily handled, its compatibility with other

ingredients is good, it has a peroxide solubilizing action,  
and it acts as a dispersing aid of the peroxide, to make  
the crosslinking effect at the time of the heating and  
kneading uniform and effective, to give a partially  
5 crosslinked thermoplastic resin whose hardness and rubber  
elasticity are balanced. By using such a compound, the  
crosslinking does not become insufficient or excessive,  
and therefore a uniform and efficient partial crosslinking  
reaction can be expected at the time of the heating and  
10 kneading.

The amount to be added of the crosslinking aid used  
in the present invention is preferably in the range of  
0.03 to 1.8 parts by weight and more preferably 0.03 to  
1.2 parts by weight, to 100 parts by weight of the  
15 thermoplastic resin component (A). By choosing the  
crosslinking aid in this range, the crosslinking proceeds  
moderately without becoming excessive, and a composition  
excellent in extrudability can be obtained without  
granular structure to occur. The amount of the  
20 crosslinking aid to be added is preferably about 1.5 to  
4.0 times, the amount of the organic peroxide to be added,  
in terms of weight.

#### Metal Hydrate (B)

The metal hydrate that can be used in the present  
25 invention includes, but is not particularly limited to,



for example, compounds having a hydroxyl group or water of crystallization, such as aluminum hydroxide, magnesium hydroxide, aluminum silicate hydrate, magnesium silicate hydrate, basic magnesium carbonate, and hydrotalcite,

5 which can be used singly or as a combination of two or more. Among these metal hydrates, aluminum hydroxide and magnesium hydroxide are preferable. It is required that

10 at least part of the metal hydrate be treated with a silane coupling agent, but a metal hydrate whose surface is not treated or a metal hydrate whose surface is treated with another surface-treating agent, such as an aliphatic acid, can additionally be used.

As the silane coupling agent used in the surface treatment of the above metal hydrate, a crosslinking  
15 silane coupling agent is preferable, for example, a silane coupling agent having a vinyl group or an epoxy group at the terminal, such as vinyltrimethoxysilane, vinyltriethoxysilane, glycidoxypropyltrimethoxysilane, glycidoxypropyltriethoxysilane,  
20 glycidoxypropylmethyldimethoxysilane, methacryloxypropyltrimethoxysilane, methacryloxypropyltriethoxysilane, and methacryloxypropylmethyldimethoxysilane; a silane coupling agent having a mercapto group at the terminal, such as  
25 mercaptopropyltrimethoxysilane and

mercaptopropyltriethoxysilane; and a silane coupling agent having an amino group, such as aminopropyltriethoxysilane, aminopropyltrimethoxysilane, N-( $\beta$ -aminoethyl)- $\gamma$ -aminopropyltripropyltrimethoxysilane, and N-( $\beta$ -

5 aminoethyl)- $\gamma$ -aminopropyltripropylmethyldimethoxysilane. Further, these silane coupling agents can be used as a combination of two or more.

Among these crosslinking silane coupling agents, silane coupling agents having an epoxy group and/or a  
10 vinyl group at their terminal are more preferable, and these may be used singly or as a combination of two or more.

As the magnesium hydroxide whose surface is treated with a silane coupling agent and that can be used in the  
15 present invention, can be mentioned those obtained by surface-treating one whose surface is untreated (e.g., commercially available Kisma 5 (trade name, manufactured by Kyowa Kagaku Co.)), one whose surface is treated with an aliphatic acid, such as stearic acid, oleic acid, or  
20 the like (e.g., Kisma 5A (trade name, manufactured by Kyowa Kagaku Co.)), and one that is treated with a phosphate, with the above silane coupling agent having a vinyl group or an epoxy group at the terminal; and a commercially available product of magnesium hydroxide  
25 whose surface has been already treated with a silane

coupling agent having a vinyl group or an epoxy group at the terminal (e.g., Kisma 5LH and Kisma 5PH (trade names, manufactured by Kyowa Kagaku Co.)).

In addition to the above ones, for example, use can  
5 be made of a metal hydrate obtained by surface-treating magnesium hydroxide or aluminum hydroxide part of whose surface is pretreated previously with an aliphatic acid, a phosphate, or the like, with a silane coupling agent having a functional group, such as a vinyl group and an  
10 epoxy group, at the terminal.

When a metal hydrate is treated with a silane coupling agent, the metal hydrate is required to be blended with the silane coupling agent previously. At that time, the silane coupling agent is added suitably in  
15 an amount sufficient for the surface treatment, and specifically it is added preferably in an amount of 0.2 to  
2 % by weight based on the metal hydrate. The silane coupling agent may be used in the form of a stock liquid or a liquid diluted with a solvent.

The amount of the metal hydrate to be added in the resin composition of the present invention is 50 to 300 parts by weight, and particularly preferably 100 to 250 parts by weight, to 100 parts by weight of the thermoplastic resin component (A). In the present  
25 invention, (i) if the amount of the metal hydrate to be

added is 50 parts by weight or more but less than 100 parts by weight, 50 parts by weight or more of the metal hydrate to 100 parts by weight of the thermoplastic resin component (A) is to be one pretreated with a silane coupling agent, or (ii) if the amount of the metal hydrate to be added is 100 parts by weight or more to 100 parts by weight of the thermoplastic resin component (A), at least half of that amount is to be one pretreated with a silane coupling agent, thereby a large amount of a filler can be blended with the resin, without lowering the mechanical strength, even if a large amount of the metal hydrate is added. It is particularly preferable to use a metal hydrate in which at least 100 parts by weight of the metal hydrate to 100 parts by weight of the thermoplastic resin component (A) is magnesium hydroxide treated with a silan coupling agent.

If a usual polyolefin resin, such as a polyethylene resin and a polypropylene resin, is used as a base resin and a large amount of a metal hydrate is added in order to satisfy the required fire retardancy, the mechanical strength is lowered very much. In contrast, the thermoplastic resin component (A) in the present invention is excellent in filler acceptability, since the crosslink density is low and the resin ingredients are in a partially crosslinked state through the ingredient (f).

Accordingly, when such a thermoplastic resin component (A) is used as a base resin, a large amount of a metal hydrate can be mixed. In particular, only when a specified amount of a metal hydrate treated with a silane coupling agent is  
5 mixed, the lowering of the mechanical strength is minimized, whitening difficultly occurs when bent, and satisfactory characteristics for covering materials of wiring materials, molded parts, etc. can be obtained.

Although the detailed reaction mechanism when  
10 heated/kneaded the resin composition of the present invention has not been clear yet, it is assumed as follows. Melting and kneading the thermoplastic resin component (A) in the present invention causes the ingredient (a) and the ingredient (c) to be crosslinked through the ingredient  
15 (f), in the presence of the ingredient (e). On the other hand, if there is the ingredient (d), by the action of the ingredient (e), (d) is made to convert to have the molecular weight lowered suitably, so that the melt viscosity of the resultant resin composition can be  
20 suitably controlled. Also by the ingredient (b) the melt viscosity of the resin composition can be controlled. Therefore the resultant composition gives a crosslinked product excellent in extrudability in its entirety. Such crosslinking of the composition of the present invention  
25 can be referred to as partial crosslinking, since the

number of crosslinked points is less in comparison to the usual crosslinking. One of reasons on the above is that crosslinking is carried out in the presence of a small amount of the ingredient (e).

5           The degree of crosslinking of the fire-retardant resin composition can be represented, as a scale, by a gel fraction and a dynamic elastic modulus of the thermoplastic resin component (A). The gel fraction can be represented by a ratio of the weight of solid residue  
10   to 1 g of a sample, wherein the solid residue is obtained in such a manner that 1 g of the sample is wrapped in a wire net (100 mesh) and it is extracted in boiling xylene for ten hours using a Soxhlet's extractor. The dynamic elastic modulus can be represented by a storage elastic  
15   modulus of melting viscoelasticity using a parallel plate.

          The degree of crosslinking in the present invention is preferably 30 to 45% by weight, and more preferably 40 to 45% by weight, in terms of the gel fraction; and it is preferably  $10^5$  to  $10^7$  Pa in terms of the storage elastic  
20   modulus.

          When the thermoplastic resin component (A) is filled with the metal hydrate, only when a specific amount of a metal hydrate treated with a silane coupling agent is added, simultaneously with the ingredient (e) and the  
25   ingredient (f), the metal hydrate can be added in a large

amount without impairing the extrudability at the time of molding. In that case, as a result, a fire-retardant resin composition can be obtained that has heat resistance and mechanical characteristics with excellent fire retardancy retained, that can be reextruded after its use, and that can be recycled.

Although the detailed mechanism wherein a metal hydrate treated with a silane coupling agent acts has not been clear yet, the mechanism is assumed as follows. The silane coupling agent that has been bonded to the metal hydrate surface as a result of the treatment with the silane coupling agent acts such that the alkoxy group at one terminal is bonded to the metal hydrate and various reactive sites including the vinyl group and the epoxy group being present at the other terminal are bonded to the uncrosslinked parts of the ingredient (a) of a vinyl aromatic thermoplastic elastomer, and the ingredient (c) of an ethylene/ $\alpha$ -olefin copolymer. Thus, a large amount of a metal hydrate can be added without impairing extrudability, the adhesion between the resin and the metal hydrate is made strong, and a fire-retardant resin composition that is good in mechanical strength and abrasion resistance and that is difficultly scarred can be obtained.

Into the fire-retardant resin composition of the

present invention, can be blended various additives generally used in electric wires, electric cables, and electric cords, such as an antioxidant, a metal inactivator, a fire-retardant (auxiliary) additive, a  
5 filler, a lubricant, and an acid anhydride and its modified product, in the range wherein the purpose of the present invention is not damaged.

As the antioxidant, can be mentioned, for example, an amine-series antioxidant, such as a polymer of 2,2,4-  
10 trimethyl-1,2-dihydroquinone, 4,4'-dioctyldiphenylamine, and N,N'-diphenyl-p-phenyldiamine; a phenol-series antioxidant, such as pentaerythrityl-tetrakis(3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate), octadecyl-3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate, and 1,3,5-trimethyl-  
15 2,4,6-tris(3,5-di-t-4-butyl-4-hydroxybenzyl)benzene; and a sulfur-series antioxidant, such as a bis(2-methyl-4-(3-n-alkylthiopropionyloxy)-5-t-butylphenyl)sulfide, 2-mercaptobenzimidazole and its zinc base, and pentaerythritol-tetrakis(3-lauryl-thiopropionate).

20 As the metal inactivator, can be mentioned, for example, N,N'-bis(3-(3,5-di-t-butyl-4-hydroxyphenyl)propionyl)hydrazine, 3-(N-salicyloyl)amino-1,2,4-triazole, and 2,2'-oxamidobis-(ethyl 3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate).

25 Further, as the fire-retardant (auxiliary) additive



and the filler, can be mentioned, for example, carbon, clay, zinc oxide, tin oxide, titanium oxide, magnesium oxide, molybdenum oxide, antimony trioxide, a silicone compound, quartz, talc, calcium carbonate, magnesium carbonate, zinc borate, and white carbon.

Particularly, a silicone compound, such as a silicone rubber and a silicone oil, has such an effect that it not only gives or improves fire retardancy, but also it controls the adhesion between the insulator (the covering layer containing the fire-retardant resin composition) and the conductor in the case of electric wires and cords as well as it gives lubricity in the case of cables, to reduce external scars. Specific examples of such a silicone compound that can be used in the present invention include such commercially available products as "SFR-100" (trade name, manufactured by GE Co.) and "CF-9150" (trade name, manufactured by Toray Dow Silicone Co.).

If added, the silicone compound is added preferably in an amount of 0.5 to 5 parts by weight to 100 parts by weight of the component (A). If the amount is less than 0.5 part by weight, it is not substantially effective for fire retardancy and lubricity. On the other hand, if the amount is over 5 parts by weight, the outer appearance of electric wires, cords, and cables is deteriorated and the extruding speed is lowered to make the productivity poor

in some cases.

As the lubricant, can be mentioned, for example, a hydrocarbon-series lubricant, an aliphatic acid-series lubricant, an aliphatic acid amide-series lubricant, an ester-series lubricant, an alcohol-series lubricant, and a metal soap-series lubricant.

As the acid anhydride and its modified product, can be mentioned, for example, maleic anhydride and a maleic anhydride-modified polyethylene. By using the acid anhydride or its modified product, the interaction between the polyolefins (the ingredients (c) and (d)) and the metal hydrate is improved. Thus, the mechanical physical properties can be improved. When added, to 100 parts by weight of the ingredient (a), preferably the acid anhydride is used in an amount of 3.0 to 8.0 parts by weight and the modified product of an acid anhydride is used in an amount of 10 to 40 parts by weight.

Into the fire-retardant resin composition of the present invention, can be introduced the above additive and another resin in the range wherein the purpose of the present invention is not impaired, but at least the above thermoplastic resin component (A) is to be its major resin components. Herein, "to be its major resin components" means that the above thermoplastic resin component (A) amounts to generally 70 % by weight or more, preferably

85 % by weight or more, and more preferably all of the resin components, in the resin components of the fire-retardant resin composition of the present invention.

Herein, in the thermoplastic resin component (A),  
5 the ingredients (a), (b), (c), and (d) each have the amount to be used within the range as specified in the above, and the sum total of the amounts of the ingredients (a) to (d) is 100% by weight of the thermoplastic resin component (f).

10 As one preferable embodiment of the resin composition of the present invention, can be shown the following.

A fire-retardant resin composition, which comprises:  
a thermoplastic resin composition (A) comprising (a)  
15 100 parts by weight of a block copolymer made up of at least two polymer blocks A mainly made of a vinyl aromatic compound as its constitutional component and at least one polymer block B mainly made of a conjugated diene compound as its constitutional component, and/or a hydrogenated  
20 block copolymer obtained by hydrogenating the block copolymer, (b) 30 to 70 parts by weight of a nonaromatic-series softening agent for rubber, (c) 10 to 60 parts by weight of a polypropylene-series resin, (d) 50 to 200 parts by weight of an ethylene/ $\alpha$ -olefin copolymer having a  
25 density of 0.91 g/cm<sup>3</sup> or less that is synthesized in the

presence of a single site catalyst, and (e) 0.1 to 1.5 parts by weight of an organic peroxide; and

100 to 250 parts by weight of a metal hydrate (B),  
to 100 parts by weight of the thermoplastic resin  
5 composition (A).

Hereinbelow, the method for preparing the fire-retardant resin composition of the present invention is described.

The ingredients (a) to (d), the metal hydrate (B),  
10 and the ingredient (e) and the ingredient (f) are added, heated, and kneaded. The kneading temperature is preferably 160 to 240 °C. The kneading conditions, such as a kneading temperature and a kneading time, can be set, so that it is enough to melt the resin ingredients (a) to  
15 (d), to realize the necessary partial crosslinking by the action of the organic peroxide. As the kneading method, a means usually used for rubbers, plastics, and the like can be satisfactorily used and, for example, as an apparatus, a single-screw extruder, a double-screw extruder, a roll,  
20 a Banbury mixer, or various kneaders can be used. In this process, a fire-retardant resin composition wherein the ingredients are uniformly dispersed can be obtained.

Meantime, when the metal hydrate (B) is in an amount of 50 parts by weight or more but less than 100 parts by  
25 weight to 100 parts by weight of the thermoplastic resin

component (A), it is required that the metal hydrate treated with a silane coupling agent be in an amount of 50 parts by weight or more; and when the metal hydrate (B) is in an amount of 100 parts by weight or more but 300 parts by weight or less, it is required that at least half in the entire amount of the metal hydrate (B) be a metal hydrate pretreated with a silane coupling agent.

In this case, it is important that the metal hydrate treated with a silane coupling agent is one that is previously treated with a silane coupling agent. By using a previously surface-treated metal hydrate, a metal hydrate can be added in an amount enough to secure fire retardancy. Therefore, a fire-retardant resin composition that is particularly good in mechanical strength and abrasion resistance and is difficultly scarred can be obtained.

As another method, the ingredients (a) to (d) are heated and kneaded in a first step, to obtain the thermoplastic resin component (A). In a second step, the ingredients (e) and (f) and the metal hydrate (B) are added to the thermoplastic resin component (A) obtained in the first step and they are heated and kneaded. At that time, the temperature is preferably 160 to 240 °C. Also in this case, the kneading conditions, such as a kneading temperature and a kneading time, can be set, so that the

thermoplastic resin component (A) can be melted and the organic peroxide contained can be used enough to carry out crosslinking.

In this way, it is possible that after the  
5 ingredients (a) to (d) are previously heated and kneaded to micro-disperse them, the ingredients (e) and (f) are added and they are heated and kneaded. In this case also, when the metal hydrate whose surface is treated is added, it is required that before the addition the metal hydrate  
10 be surface-treated previously.

The fire-retardant resin composition of the present invention is suitable for wiring materials used in inner and outer wiring of electric/electronic equipment, and for covering or preparing molded parts including optical fiber  
15 core wires, optical fiber cord wires, etc.

When the resin composition of the present invention is used as a covering material of a wiring material, there is no particular restriction except that the outer circumference of a conductor is provided with at least one  
20 covering layer made of the above fire-retardant resin composition of the present invention, preferably formed by extrusion coating. It is particularly preferable to use the fire-retardant resin composition, in which at least 100 parts by weight among the total metal hydrate, to 100  
25 parts by weight of the thermoplastic resin component (A),

is magnesium hydroxide being treated with a silan coupling agent. As the conductor, for example, any known one, such as a solid wire or a stranded wire of annealed copper, can be used. Further, as the conductor, a conductor plated with tin or having an enameled insulating layer can be used, in addition to an open wire.

The wiring material of the present invention can be prepared by extrusion-coating the circumference of a conductor or an insulated wire, with the fire-retardant resin composition of the present invention, by using a general-purpose extrusion-coating apparatus. At that time, the temperature of the extrusion-coating apparatus is preferably about 180 °C at the cylinder part and about 200 °C at the crosshead part.

In the wiring material of the present invention, the thickness of the insulating layer (a covering layer made of the fire-retardant resin composition of the present invention) formed around the conductor is not particularly limited, but it is generally of the order of 0.15 to 5 mm.

Further, in the wiring material of the present invention, although the resin composition of the present invention is preferably extrusion-coated to form a covering layer as it is, it is also possible to further crosslink the extruded covering layer in order to improve the heat resistance further. However, if this

crosslinking is carried out, it becomes difficult to reuse (recycle) the covering layer as an extrusion material.

As a method for crosslinking, the usually practiced electron beam irradiation crosslinking method and chemical crosslinking method can be employed.

In the case of the electron beam crosslinking method, after the resin composition is extruded to form a covering layer, it is irradiated with an electron beam in a usual manner, to carry out the crosslinking. The dosage of the electron beam is suitably 1 to 30 Mrad, and in order to carry out the crosslinking efficiently, the resin composition that will constitute the covering layer may be blended with, as a crosslinking aid, a polyfunctional compound, such as a methacrylate-series compound (e.g. trimethylolpropane triacrylate), an allyl-series compound (e.g. trially cyanurate), a maleimide-series compound, and a divinyl-series compound.

In the case of the chemical crosslinking method, the resin composition is blended with an organic peroxide as a crosslinking agent, and after the extrusion is carried out to form a covering layer, it is subjected to crosslinking by heating in a usual manner.

The optical fiber core wire or the optical cord of the present invention is produced, by extrusion-coating the fire-retardant resin composition of the present



invention, using a general-purpose extrusion-coating apparatus, to form a covering layer around an optical fiber element wire, or around an optical fiber core wire having tensile strength fibers placed along it or

5 intertwined therewith. At that time, the temperature of the extrusion-coating apparatus is preferably about 180 °C at the cylinder section and about 200 °C at the crosshead section.

The optical fiber core wire of the present invention  
10 is used as it is, without providing a further covering layer around it in some applications.

Meantime, the optical fiber core wire or cord of the present invention includes all that has the covering around the optical fiber element wire or core wire with  
15 the covering layer made of the fire-retardant resin composition of the present invention, and its structure is not particularly restricted. The thickness of the covering layer, the type and amount of the tensile strength fibers placed along or intertwined with the  
20 optical fiber core wire, etc. varies, for example, depending on the type and application of the optical fiber cord and they can be set arbitrarily.

Figs. 1 to 3 show examples of the structure of the optical fiber core wire and cord of the present invention.

25 Fig. 1 is a cross-sectional view of an example of

the optical fiber core wire of the present invention,  
wherein the outer circumference of an optical fiber  
elemental wire 1 is directly provided with a covering  
layer 2 made of the fire-retardant resin composition.

5           Fig. 2 is a cross-sectional view of an example of  
the optical fiber cord of the present invention, wherein a  
covering layer 5 is formed on the outer circumference of  
one optical fiber core wire 3 having a plurality of  
tensile strength fibers 4 placed along it longitudinally.

10           Fig. 3 is a cross-sectional view of an example of  
the optical fiber cord (optical fiber two-core cord) of  
the present invention, wherein a plurality of tensile  
strength fibers 4 are placed along each of the outer  
circumferences of two optical fiber core wires 3 and 3,  
15           and a covering layer 6 is formed on each of the outer  
circumferences thereof.

          The shape of the molded part of the present  
invention is not particularly restricted, and examples of  
it include a power source plug, a connector, a sleeve, a  
20           box, a tape base material, a tube, a sheet, and the like.  
The molded part of the present invention is molded out of  
the fire-retardant resin composition of the present  
invention by a molding method, such as usual injection-  
molding.

25           According to the present invention, a fire-retardant

resin composition and a wiring material that are excellent in fire retardancy, heat resistance, and mechanical characteristics, and that neither exude heavy metal compounds nor produce a large amount of smoke or corrosive gases when discarded, for example, to be buried or burned, can be provided, so that recent environmental problems may be cleared. Further, according to the present invention, a fire-retardant resin composition that gives a covering material that can be remelted, to allow it to be reused (recycled), can be provided; that is not whitened when bent, and that is not easily scarred, while satisfying the above characteristics, as well as a wiring material, an optical fiber core wire, an optical fiber cord, and other molded parts, in which the fire-retardant resin composition is used, respectively, can be provided.

The fire-retardant resin composition of the present invention is made up of a halogen-free fire-retardant material not containing phosphorus; accordingly, not only is the composition excellent in mechanical characteristics, fire retardancy, heat resistance, and flexibility, but also it neither exudes harmful heavy metal compounds nor produces a large amount of smoke or corrosive gases when discarded, for example, to be buried or burned.

Further, the wiring material of the present invention is excellent in mechanical characteristics, fire

retardancy, and heat resistance, as well as flexibility,  
and particularly it is not whitened when bent. Thus, the  
wiring material of the present invention is a halogen-free  
fire-retardant wiring material not containing phosphorus  
5 that is excellent in both flexibility and mechanical  
strength.

Further, since the covering layer of the wiring  
material of the present invention has a high heat  
resistance of UL 105 °C, and it can be made of a  
10 remeltable material as a covering material, a wiring  
material can be provided that is rich in recyclability, in  
comparison to conventional wiring materials covered with a  
current covering material that is a crosslinked product.

Thus, the wiring material of the present invention  
15 is very useful as a wiring material for  
electric/electronic equipment, such as power source cables,  
wherein environmental problems are taken into  
consideration.

Further, the fire-retardant resin composition of the  
20 present invention is preferably suitable as a covering  
material for such a wiring material, an optical fiber core  
wire, and an optical fiber cord, as a material for molded  
parts, and also as a tube material, as well as a tape  
material.

25 Hereinbelow, the present invention is described in

more detail with reference to the following examples, but the invention is not limited to those.

#### EXAMPLES

5           In the followings, unless otherwise stated, numerical values mean part(s) by weight.

##### Examples 1 to 19 and Comparative Examples 1 to 12

Use was made of, as the ingredient (a), a hydrogenated styrene/ethylene/propylene/styrene copolymer (SEPS), as the ingredient (b), a paraffin oil, as the ingredient (c), an ethylene/1-octene copolymer having a density of 0.87 g/cm<sup>3</sup> (c-1), an ethylene/1-octene copolymer having a density of 0.915 g/cm<sup>3</sup> (c-2), or a straight-chain low-density polyethylene having a density of 0.925 g/cm<sup>3</sup> (c-3), as shown in Tables 1-6, as the ingredient (d), a polypropylene (MFR: 8g/10 min) (d-1) or (d-2), as shown in Tables 1-6, as the ingredient (e), 2,5-dimethyl-2,5-di(t-butylperoxy)-hexane, as the ingredient (f), triethylene glycol dimethacrylate, and as the component (B), magnesium hydroxide whose surface had been treated with a vinyl silane (B-1), magnesium hydroxide whose surface had been treated with an aliphatic acid (B-2), or untreated magnesium hydroxide (B-3) and a silane coupling agent, and these components were blended in the amount to be added as shown in Tables 1-6, to prepare

compositions, respectively.

In Examples 3 and 7, the ingredients (a) to (d) were dryblended at room temperature and were heated and kneaded at 200 °C in a Banbury mixer, to prepare a thermoplastic resin component (A). Then, the ingredients (e) and (f) and the metal hydrate (B) were charged and they were kneaded in the Banbury mixer and were discharged, to obtain a fire-retardant resin composition, respectively. The discharge temperature was 200 °C.

10 In Examples 11 and 13, the metal hydrate (B) was placed in a blender and the silane coupling agent was added, dropwise, with stirring, so that the metal hydrate was treated with the silane coupling agent previously. The thus-obtained metal hydrate, whose surface had thus  
15 been treated with the silane coupling agent, and all the other components were dryblended at room temperature, were heated and kneaded in a Banbury mixer at 200 °C, and then were discharged, to obtain fire-retardant resin compositions. The discharge temperature was 200 °C.

20 In other Examples and Comparative Examples (excluding Comparative Examples 8 and 9), all the components were dryblended at room temperature, were heated and kneaded in a Banbury mixer at 200 °C, and then were discharged, to obtain fire-retardant resin  
25 compositions. The discharge temperature was 200 °C.

In Comparative Example 8, after all the components, except the organic peroxide and the silane coupling agent, were heated and kneaded in a Banbury mixer, the organic peroxide and the silane coupling agent were charged,  
5 followed by kneading.

In Comparative Example 9, after all the components except the metal hydrate (B) were kneaded in a Banbury mixer, the metal hydrate (B) was added, followed by kneading and discharging, to obtain a fire-retardant resin  
10 composition.

From the thus-obtained resin compositions, 1-mm sheets corresponding to the Examples and the Comparative Examples were obtained by pressing.

Then, using an extrusion-coating apparatus for  
15 production of electric wires, each of the resin compositions for insulation-covering that had been previously melted was extruded to cover a conductor (a stranded annealed copper wire with tinning having a diameter of 1.14 mm $\phi$  and composed of 30 wires each having  
20 a diameter of 0.18 mm $\phi$ ), to prepare insulated wires having an outer diameter of 2.74 mm, respectively corresponding to Examples 1 to 17 and Comparative Examples 1 to 12.

Further, using a general-purpose extrusion-coating apparatus, the thus-obtained composition was extruded to  
25 form a covering in thickness of 0.35 mm around the outer

circumference of an optical fiber polyamine (nylon) core wire (3) having an outer diameter ( $\phi$ ) of 0.90 mm along which tensile strength fibers (aramid fibers) (4) were placed, to make an optical fiber cord having the structure as shown in Fig. 2; alternatively, the thus-obtained composition was made to cover directly an optical fiber element wire (1) having a diameter of  $\phi$  0.25 mm, to make an optical fiber core wire having an outer diameter of 0.9 mm and having the structure as shown in Fig. 1 (Examples 1, 2, and 9).

Further, using the thus-obtained compositions in Examples 18 and 19, injection-molding with an injection-molding machine was made on power source plug terminals having two electric wires connected thereto, wherein the electric wires were produced in accordance with Example 2, to produce power source plugs, respectively. These power source plugs were molded at an injection-molding temperature of 230 °C.

As to the thus-obtained sheets, the tensile properties (extension (elongation) (%) and tensile strength (MPa)) and the heat deformation property were evaluated. The results are also shown in Tables 1 to 6. The properties were evaluated on the basis of JIS K 6723 and the heat deformation test was carried out at 121 °C.

As to properties of the sheets, it was judged to



pass the tests, when the extension was 100% or more, when the tensile strength was 10 MPa or more, and when the heat deformation rate was 30% or less.

Further, regarding the covering layers of the thus-  
5 obtained insulated wires, the tensile properties, the abrasion resistance, the horizontal flame test, the 60°-inclined flame test, the heat deformation rate test, the whitening test (whether there was observed a whitening phenomenon when bent), the extrudability test, and the  
10 flexibility test were carried out, to evaluate these properties. The results are also shown in Tables 1 to 6.

Regarding the tensile properties, the tensile strength (MPa) and the breaking extension (elongation) (%) of the insulators (covering layers) of the insulated wires  
15 were measured under conditions with the bench mark distance being 25 mm and the rate of pulling being 500 mm/min. The extension is required to be 100% or more and the mechanical strength is required to be 10 MPa or more.

The abrasion resistance was evaluated using the test  
20 apparatus whose front view is shown in Fig. 4. The insulated wire (7), cut to a length of 75 cm with the conductor (7b) exposed by removing the insulating-covering layer (7a) at both of the opposite ends, was fixed on a horizontal table (8) with a clamp (9); and then a blade  
25 (11) was moved back and forth alternately (in the

direction shown by the arrow in the figure) 50 to 60 times per minute, over a length of 10 mm or more along the longitudinal direction of the insulated wire, with a load (10) of 700 gf being applied, until the insulating-  
5 covering layer was removed by the abrasion to allow the blade to come in contact with the conductor of the electric wire, the number required of the reciprocative movements of the blade being counted. A front view of the blade is shown in Fig. 5, wherein the blade (11) has a  
10 blade section having a width of 3 mm defined by two faces (11a, 11b) forming an angle of 90° and the curvature radius (R) of the tip of the blade section is 0.125 mm. The one wherein the number of the reciprocative movements of the blade at which it came in contact with the  
15 conductor of the electric wire was 1,000 or more was rated "○", the one wherein that number was 500 or more but less than 1,000 was rated "△", and the one wherein that number was less than 500 was rated "×" which meant an unacceptable one. The ratings "○" and "△" are on the  
20 practically acceptable level and show that they are qualified (passed the test).

In the horizontal flame test, the insulated wires were subjected to the horizontal flame test stipulated in JIS C 3005, and when the burning went out by itself within  
25 30 sec, it was judged to pass the test, and the number

passed the test out of ten samples was counted and shown in Tables.

In the 60-degree flame test, the insulated wires were subjected to the 60°-inclined flame test stipulated in JIS C 3005, and when the burning went out by itself within 30 sec, it was judged to pass the test, and the number passed the test out of ten samples was counted and shown in Tables.

Further, with respect to fire retardancy, it is not necessary to pass both of the above two kinds of flame tests. When all samples to be tested were passed the test of the horizontal flame test, it is judged to pass the fire retardancy.

The heat deformation rate was measured by carrying out the deformation test of UL1581 with the temperature being 121 °C and the load being 500 gf, to obtain the rate (%) of the deformation after the heating to before the heating. The one having a heat deformation rate of 50% or more cannot be practically used.

The whitening phenomenon whether it would be observed or not, was evaluated by the observation whether there was whitening when the insulated wire was wound around a mandrel having the same diameter as that of the insulated wire. After winding 6 times, if there was no whitening, it was rated "○", if there was observed

whitening upto 5 times, it was rated " $\Delta$ ", and if there was whitening 6 times or more, it was rated " $\times$ ". The one rated " $\times$ " is practically unpreferable.

In the extrudability test, the extrusion was carried out with a 30-mm $\phi$  diameter extruding machine; when the extrusion could be carried out with the motor load in the normal range and the outer appearance was good, it was rated " $\bigcirc$ ", when the extrusion was carried out with the extrusion load being a little large or the outer appearance was a little poor, it was rated " $\Delta$ ", and when the extrusion load was conspicuously large and the extrusion was difficult or impossible, it was rated " $\times$ ". The ratings " $\bigcirc$ " and " $\Delta$ " are on the practically acceptable level with no problems to occur and are judged to pass the test.

The flexibility was evaluated by the test method shown in Fig. 6 schematically. Each of the insulated wires was cut into a length of 20 cm to be used as a sample (12), one end of it was fixed to a vertical wall (13), and the difference L (cm) between the level of the fixed one end and the level of the other end that was lowered by its weight was measured. The one wherein the difference (L) was less than 1 cm, it was rated " $\times$ ", the one wherein the deference (L) was 1 cm or more but less than 3 cm, it was rated " $\Delta$ ", and the one wherein the

difference (L) was 3 cm or more, it was rated "○". The one rated "×" is poor in flexibility and cannot be practically used as an insulated wire.

The compounds that were used, as shown in Tables 1 to 6, were as follows:

The thermoplastic resin component (A)

Ingredient (a): a hydrogenated block copolymer

Manufacturing company: Kuraray Co., Ltd.

Trade name: Septon 4077

10 Type: a styrene/ethylene/propylene/styrene copolymer

Styrene component content: 30% by weight

Isoprene component content: 70% by weight

Weight-average molecular weight: 320,000

Molecular weight distribution: 1.23

15 Hydrogenated rate: 90% or more

Ingredient (b): a nonaromatic-series softener for rubber

Manufacturing company: Idemitsu Kosan Co., Ltd.

Trade name: Diana Process Oil PW-90

Type: a paraffin-series oil

20 Weight-average molecular weight: 540

Aromatic component content: 0.1% or less

Ingredient (c): a single site catalyst-series ethylene/ $\alpha$ -olefin copolymer

(c-1)

25 Manufacturing company: Dow Chemical Japan Ltd.

[illegible]

Manufacturing company: Nippon Oil and Fats Co., Ltd.

Trade name: Perhexa 25B

Type: 2,5-dimethyl-2,5-di(t-butylperoxy)-hexane

Ingredient (f): a crosslinking aid

5 Manufacturing company: Shin-Nakamura Kagaku Co.

Trade name: NK Ester 3G

Type: triethylene glycol dimethacrylate

(B) Metal hydrate

(B-1)

10 Manufacturing company: Kyowa Chemical Co., Ltd.

Trade name: Kisma 5LH

Type: magnesium hydroxide whose surface was treated  
with a silane coupling agent having a vinyl  
group at the terminal

15 (B-2)

Manufacturing company: Kyowa Chemical Co., Ltd.

Trade name: Kisma 5B

Type: magnesium hydroxide treated with an aliphatic  
acid

20 (B-3)

Manufacturing company: Kyowa Chemical Co., Ltd.

Trade name: Kisma 5

Type: untreated magnesium hydroxide

(Silane coupling agent)

25 TSL8370 (trade name)

Manufacturing company: Toshiba Silicone Co., Ltd.

Type: a silane coupling agent having a vinyl group  
at the terminal

TSL8350 (trade name)

5 Manufacturing company: Toshiba Silicone Co., Ltd.

Type: a silane coupling agent having an epoxy group  
at the terminal

Other components

A maleic acid-modified polyethylene (LLDPE)

10 Manufacturing company: Mitsui Chemicals, Inc.

Trade name: ADMER XE070

Type: a maleic acid-modified polyethylene

A phenol-series antioxidant

Manufacturing company: Ciba-Geigy Co.

15 Trade name: Irganox 1010

Type: pentaerythritol tetrakis(3-(3,5-di-t-butyl-4-  
hydroxyphenyl)propionate)

Lubricant

Manufacturing company: Hoechst Co.

20 Trade name: Wax OP

Type: montanoic acid-saponified ester wax



Table 1

	SEPS	Example	1	2	3	4	5	6	7
a	Paraffin oil		100	100	100	100	100	100	100
b	Ethylene/ $\alpha$ -olefin copolymer (0.870)		40	76	15	90	40	70	40
c-1	Ethylene/ $\alpha$ -olefin copolymer (0.915)		133	81	80	60	100	370	133
c-2	Ethylene/ $\alpha$ -olefin copolymer (0.925)								
c-3	Block polypropylene		33					30	33
d-1	Random polypropylene				10	10	180		
d-2	Organic peroxide		0.66	0.54	0.4	0.52	0.9	1.23	0.66
e	Crosslinking aid		2	1.6	1.2	1.56	2.7	3.7	2
f	Maleic acid-modified LLDPE		27	21	16	21	33	46	27
B-1	Kisma 5LH		500	405	331	421	680	924	233
B-2	Kisma 5B								
B-3	Kisma 5								
	TSL8370								
	Antioxidant		3	2.5	2.2	2.8	4.5	6.1	3
	Lubricant		6	5	4.4	5.6	9.0	12.2	6
Properties of the sheet	Extension (%)		200	280	150	360	200	170	230
	Tensile strength (MPa)		19	13	20	12	14	20	14
	Heat deformation 121 °C		13	15	11	16	9	15	15
Characteristics of the electric wire	Extension (%)		220	290	140	380	240	200	280
	Tensile strength (MPa)		20	14	21	13	15	22	13
	Horizontal flame test		10/10	10/10	10/10	10/10	10/10	10/10	10/10
	60°-inclined flame test		10/10	10/10	10/10	10/10	10/10	10/10	0/10
	Abrasion resistance		○	○	○	○	○	○	○
	Whitening		○	○	○	○	△	○	○
	Heat deformation (%)		21	23	18	25	14	21	23
	Extrudability		○	○	△	○	○	○	○
	Flexibility		○	○	○	○	△	○	○

Table 2

	Example	8	9	10	11	12	13	14
a	SEPS	100	100	100	100	100	100	100
b	Paraffin oil	40	76	40	40	40	40	40
c-1	Ethylene/ $\alpha$ -olefin copolymer (0.870)	133	81	133	133	133	133	
c-2	Ethylene/ $\alpha$ -olefin copolymer (0.915)							133
c-3	Ethylene/ $\alpha$ -olefin copolymer (0.925)							
d-1	Block polypropylene							
d-2	Random polypropylene	33		33	33	33	33	33
e	Organic peroxide	0.66	0.54	0.66	0.66	0.66	0.66	0.66
f	Crosslinking aid	2	1.6	2	2	2	2	2
	Maleic acid-modified LLDPE	27	21	27	27	27	27	27
B-1	Kisma 5LH	930	778	300		200		500
B-2	Kisma 5B			200		133		
B-3	Kisma 5				500		500	
	TSL8370				5		4	
	TSL8350						1	
	Antioxidant	3	2.5	3	3	3	3	3
	Lubricant	6	5	6	6	6	6	6
Properties of the sheet	Extension (%)	170	200	390	230	290	150	200
	Tensile strength (MPa)	12	11	12	15	11	22	21
	Heat deformation 121 °C	11	13	13	13	16	13	13
	Extension (%)	180	210	390	250	300	160	220
Characteristics of the electric wire	Tensile strength (MPa)	12	12	12	15	11	24	21
	Horizontal flame test	10/10	10/10	10/10	10/10	10/10	10/10	10/10
	60°-inclined flame test	10/10	10/10	10/10	10/10	0/10	10/10	10/10
	Abrasion resistance	$\Delta$	$\Delta$	$\Delta$	$\Delta$	$\Delta$	$\Delta$	$\Delta$
	Whitening	$\Delta$	$\Delta$	$\Delta$	$\Delta$	$\Delta$	$\Delta$	$\Delta$
	Heat deformation (%)	19	20	21	21	26	21	21
	Extrudability	$\Delta$	$\Delta$	$\Delta$	$\Delta$	$\Delta$	$\Delta$	$\Delta$
	Flexibility	$\Delta$	$\Delta$	$\Delta$	$\Delta$	$\Delta$	$\Delta$	$\Delta$

Table 3

a	Example		15	16	17
	SEPS		100	100	100
b	Paraffin oil		40	70	20
c-1	Ethylene/ $\alpha$ -olefin copolymer (0.870)			35	167
c-2	Ethylene/ $\alpha$ -olefin copolymer (0.915)				
c-3	Ethylene/ $\alpha$ -olefin copolymer (0.925)	133			
d-1	Block polypropylene				
d-2	Random polypropylene	33	43		33
e	Organic peroxide	0.66	2.8		0.2
f	Crosslinking aid	2	3		0.4
	Maleic acid-modified LLDPE	27	27		17
B-1	Kisma 5LH	500	290		500
B-2	Kisma 5B				
B-3	Kisma 5				
	TSL8370				
	TSL8350				
	Antioxidant	3			
	Lubricant	6			
Properties of the sheet	Extension (%)	230	190		300
	Tensile strength (MPa)	22	15		10
	Heat deformation 121 °C	13	28		15
	Extension (%)	200	210		330
Characteristics of the electric wire	Tensile strength (MPa)	22	15		11
	Horizontal flame test	10/10	10/10		10/10
	60°-inclined flame test	10/10	5/10		10/10
	Abrasion resistance	○	○		△
	Whitening	○	○		○
	Heat deformation (%)	21	42		25
	Extrudability	○	△		○
	Flexibility	○	○		○

Table 4

	Example	18	19
a	SEPS	100	100
b	Paraffin oil	40	76
c-1	Ethylene/ $\alpha$ -olefin copolymer (0.870)	133	81
c-2	Ethylene/ $\alpha$ -olefin copolymer (0.915)		
c-3	Ethylene/ $\alpha$ -olefin copolymer (0.925)		
d-1	Block polypropylene	33	
d-2	Random polypropylene		
e	Organic peroxide	0.66	0.54
f	Crosslinking aid	2	1.6
	Maleic acid-modified LLDPE	27	21
B-1	Kisma 5LH	333	270
B-2	Kisma 5B		
B-3	Kisma 5		
	TSL8370		
	Antioxidant	3	2.5
	Lubricant	6	5
Properties of the sheet	Extension (%)	240	320
	Tensile strength (MPa)	16	15
	Heat deformation 121 °C	16	19
Characteristics of the molded plug	Outer appearance	○	○
	Fire retardancy	pass	pass

Table 5

Comparative Example		1	2	3	4	5	6	7
a	SEPS	100	100	100	100	100	100	
b	Paraffin oil	40	3	130	40	70	40	
c-1	Ethylene/ $\alpha$ -olefin copolymer (0.870)	133	80	60	100	550	133	
c-2	Ethylene/ $\alpha$ -olefin copolymer (0.915)							
c-3	Ethylene/ $\alpha$ -olefin copolymer (0.925)							
d-1	Block polypropylene					30		90
d-2	Random polypropylene	33	10	10	230		33	
e	Organic peroxide	0.66	0.4	0.64	1	1.6	0.66	
f	Crosslinking aid	2	1.2	1.93	3	4.8	2	
	Maleic acid-modified LLDPE	27	16	21	33	46	27	10
B-1	Kisma 5LH		313	481	754	1200	150	150
B-2	Kisma 5B	500						
B-3	Kisma 5							
	TSL8370							
	TSL8350							
	Antioxidant	3	2.1	3	5	8	3	1
	Lubricant	6	4.2	6	10	16	6	2
Properties of the sheet	Extension (%)	520	100	390	230	150	300	180
	Tensile strength (MPa)	6	18	9	15	23	8	11
	Heat deformation 121 °C	20	11	17	9	15	17	6
	Extension (%)	530	140	380	240		320	230
Characteristics of the electric wire	Tensile strength (MPa)	6	21	9	15		14	12
	Horizontal flame test	10/10	10/10	10/10	10/10		0/10	10/10
	60°-inclined flame test	10/10	10/10	10/10	10/10		0/10	10/10
	Abrasion resistance	$\Delta$	$\bigcirc$	$\Delta$	$\Delta$		$\bigcirc$	$\Delta$
	Whitening	$\times$	$\bigcirc$	$\bigcirc$	$\times$		$\bigcirc$	$\times$
	Heat deformation (%)	35	18	26	14		25	12
	Extrudability			$\bigcirc$				
		$\bigcirc$	$\times$	Bleeding occurred after extrusion	$\bigcirc$		$\bigcirc$	$\Delta$
Flexibility		$\bigcirc$	$\times$	$\bigcirc$	$\times$		$\bigcirc$	$\times$

Table 6

Comparative Example		8	9	10	11	12
a	SEPS	100	100	100	100	100
b	Paraffin oil	40	40	40	40	
c-1	Ethylene/ $\alpha$ -olefin copolymer (0.870)	133	133	133	133	80
c-2	Ethylene/ $\alpha$ -olefin copolymer (0.915)					
c-3	Ethylene/ $\alpha$ -olefin copolymer (0.925)					
d-1	Block polypropylene					
d-2	Random polypropylene	33	33	33	33	10
e	Organic peroxide	0.66	0.66	3.5	0.05	0.4
f	Crosslinking aid	2	2	4	0.2	1.2
	Maleic acid-modified LLDPE	27	27	27	27	16
B-1	Kisma 5LH		500	500	500	313
B-2	Kisma 5B					
B-3	Kisma 5	500				
	TSL8370	5				
	TSL8350					
	Antioxidant	3	3	3	3	2.1
	Lubricant	6	6	6	6	4.2
Properties of the sheet	Extension (%)		320		450	
	Tensile strength (MPa)		7		7	
	Heat deformation 121 °C		20		25	
	Extension (%)		170		420	
Characteristics of the electric wire	Tensile strength (MPa)		7		7	
	Horizontal flame test	Extrusion was impossible	10/10	Uniform kneading was impossible	10/10	Extrusion was impossible
	60°-inclined flame test		10/10		10/10	
	Abrasion resistance		○		×	
	Whitening		○		○	
	Heat deformation (%)		32		39	
	Extrudability		○		○	
	Flexibility		○		○	

As is apparent from the results shown in Tables 1 to 6, the fire-retardant resin compositions obtained in Examples 1 to 17, and the sheets, electric wires, optical fiber core wires, and optical fiber cords obtained using the same, had the required extension and the required tensile strength; they were good in the flame test, the abrasion resistance test, the whitening test, and the heat deformation rate, and they were excellent in extrudability and flexibility. In Examples 18 and 19, molded plugs were obtained, wherein there was little shrinkage of the material after the molding, and the outer appearance was good. Further, it was confirmed that, when the power source plug section was exposed to the flame of a burner used in the fire retardancy test stipulated in JIS C 3005 for 15 sec, and then the flame was withdrawn, immediately the burning died out.

In contrast, in Comparative Examples 1 to 12, uniform kneading or extrusion was impossible, or there was a problem related to any of tensile strength, whitening, extrudability, and flexibility, and no electric wire good in all the properties was obtained. In this connection, the compound of Comparative Example 8, wherein pretreatment with a silane coupling agent was not effected, and after the addition of magnesium hydroxide, a silane coupling agent and an organic peroxide were added, was

difficult to be remolded, there were many granular structures on the surface of the sheet, and extrusion was impossible. In the electric wire of Comparative Example 3, extrusion could be carried out, but bleeding occurred.

5           Further, in Comparative Example 9, wherein, after the completion of the partial crosslinking reaction, a vinyl silane-treated magnesium hydroxide was added, the effect of improving mechanical properties of electric wires could not be obtained satisfactorily. It can be  
10 understood that the effect is not observed unless the metal hydrate is added before or at the same time with the partial crosslinking reaction.

          Having described our invention as related to the present embodiments, it is our intention that the  
15 invention not be limited by any of the details of the description, unless otherwise specified, but rather be construed broadly within its spirit and scope as set out in the accompanying claims.